KNOWLEDGE

NO. 150 VOLUME 13 The colour magazine which grows into an encyclopaedia EVERY MONDAY 2/-

Seymour 3/-

ATTENTION ALL READERS!

In this issue:

The alphabetically arranged Table of Contents for Volumes 1–12.

This is not designed to be bound into your encyclopaedia but it may be kept loose for easy reference.

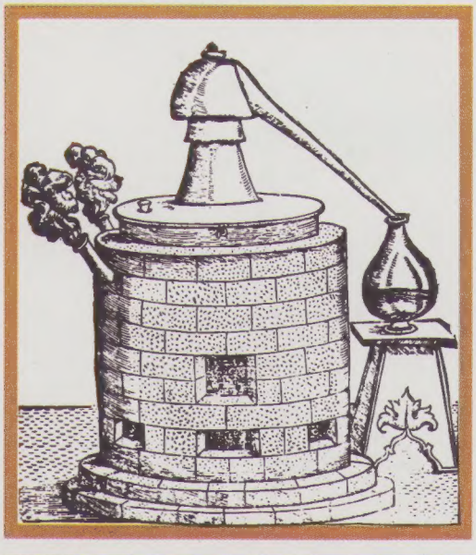
B BOTANY

BOTANY is the name given to the scientific study of plants. It is a branch of *biology*, the study of living things, and can be regarded as equivalent to *zoology*, which is the study of animal life.

Botany is one of the oldest of the sciences. Even in the Old Stone Age, before man began to cultivate plants for food, he certainly ate fruit and edible leaves and roots. It was vitally necessary that he should know which kinds were safe and good to eat and which were nasty or poisonous. Information on how to recognise plants on this basis must have been passed down from parents to children; to make sure of distinguishing between them the 'good' and 'bad' plants were probably given names, and in this way the science of botany was born.

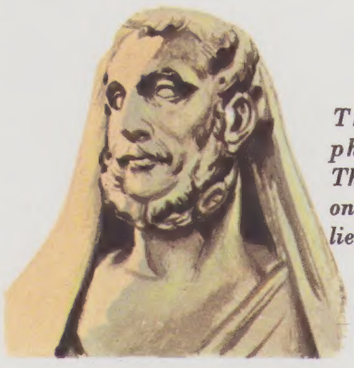
Later, in the New Stone Age, men began to cultivate plants for food, saving the seed and sowing it at the proper time during the next season. To do this they had to learn not only how to distinguish one plant from another but how to treat growing plants so that they would flourish, to gauge what soil suited them best, and at what season they must be sown and harvested. All these things come within the scope of botanical science.

An ancient alembic used for distilling the essence of plants to serve as medicine



The earliest botanists

The study of botany seems first to have attained scientific status among the Greeks. It is almost certain that Aristotle studied and wrote about plants as well as animals, but none of his botanical works have survived. His pupil Theophrastus, however, made an attempt to classify plants and to describe their various parts and their uses to man. Theophrastus wrote about 300 B C and his work, translated into Latin under the title *Historia Plantarum*, has survived to the present day. It contains a list of 455 kinds of plants.



The Greek philosopher Theophrastus, one of the earliest botanists

The Roman writer Pliny (A D 23–79) included botany among the subjects he wrote of in his great book on natural history, but his information was collected from the work of other authors. He was very uncritical in selecting his material and did not distinguish between fact and fable.

At about the same time a Greek physician, Dioscorides, who lived in Sicily, wrote a book in which he described about 600 species of plants which he regarded as of value in medicine. Dioscorides was the first writer to use the term 'botany' to designate the study of plants.

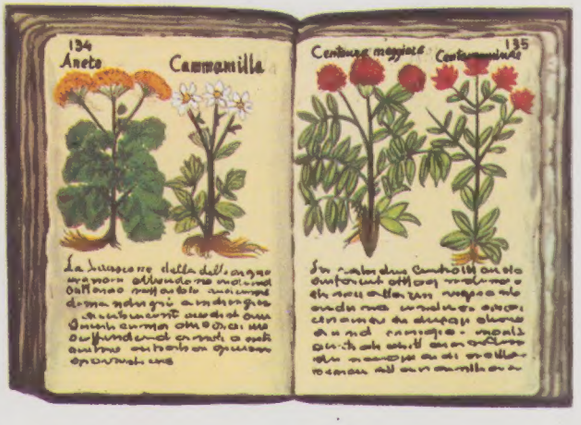
Botany in the Renaissance

These classical works were lost during the Dark Ages of European history, but rediscovered in the Renaissance. It was the fashion of this time to rely on classical authors for much information on scientific subjects. In the 15th and 16th centuries a number of '*herbals*', books on medicinal plants, were produced based on Dioscorides's work. Although he had written almost entirely about plants of the Mediterranean region, scholars working in Britain or northern Europe would try to fit their plants to his descriptions, so it is not surprising that little progress was made in scientific botany.

Scientific classification

The 17th century saw the beginning of the break-away from the classical tradition, and in 1623 Gaspard Bauhin published his famous *Pinax theatri botanici*, in which about 6,000 species of plants were listed and described.

In the same century the Englishman John Ray (1627–1705) produced the earliest scheme of natural classification in which the two great groups of flowering plants, the monocotyledons and dicotyledons, were first recognised. Many of the subdivisions he established are still recognised. Still, however, there was no satisfactory system of naming. Botanists in different countries used the plant names of their own languages



A hand-written herbal of the 17th century

Previous page: Above: a botanical study by Leonardo da Vinci. Below: four stages in plant evolution.

KINGS VERSUS BARONS, 1215–1399

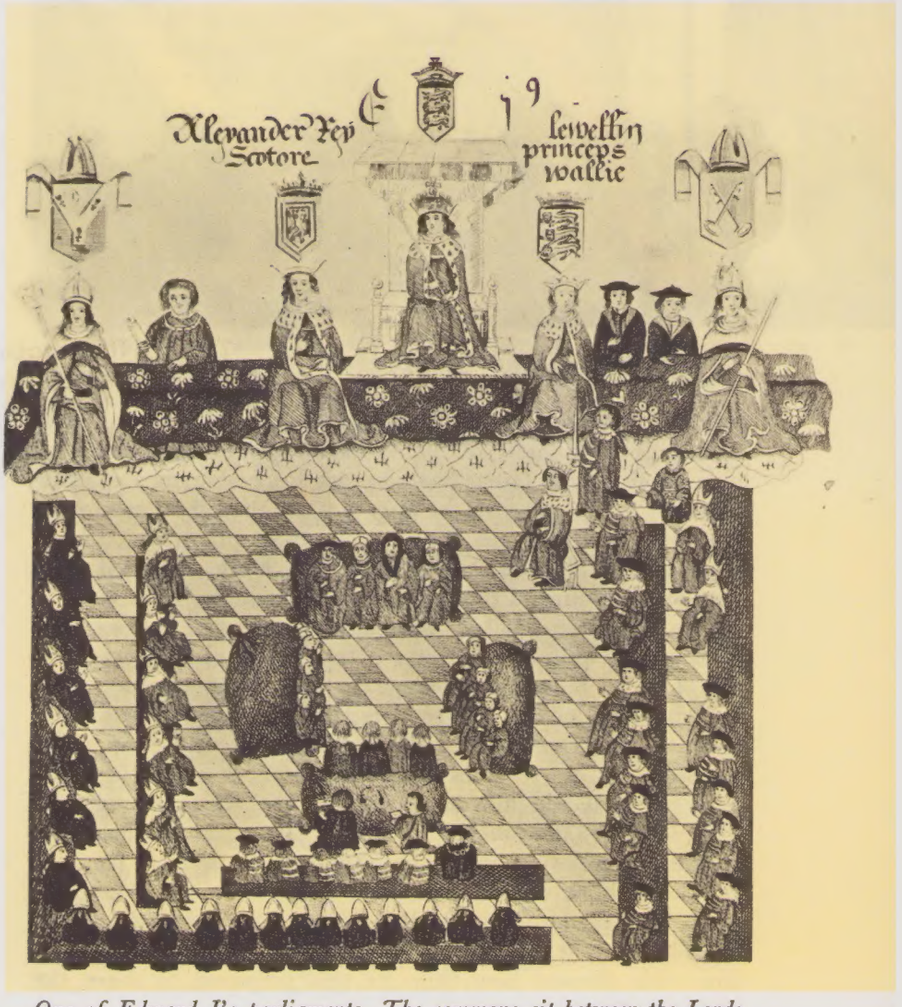
MEDIAEVAL England resounds with the names of powerful kings – the tyrant John, the great Edward I, courageous Richard the Lionheart, and the warlike Edward III and Henry V. But there are other great names: Simon de Montfort, Thomas of Lancaster, John of Gaunt, the mighty Marcher lords of the Welsh borders, and so on. How did the king regard these powerful subjects? Did he ever fear that they might become too strong? Such suspicions troubled many kings and the magnates were quite definite about their views on the monarchy: they would respect the king only if he respected them and sought their advice and consent in governing.

Usually king and magnates co-operated. Yet there were times when a foolish or tyrannical king might upset the greatest men in his land, his barons; or times when unscrupulous and ambitious nobles might seek more power than was their due. Then there was trouble, and the results make dramatic and bloody splashes on the pages of mediaeval history. They ended in the deaths of five kings and many scores of the greatest men in the land.

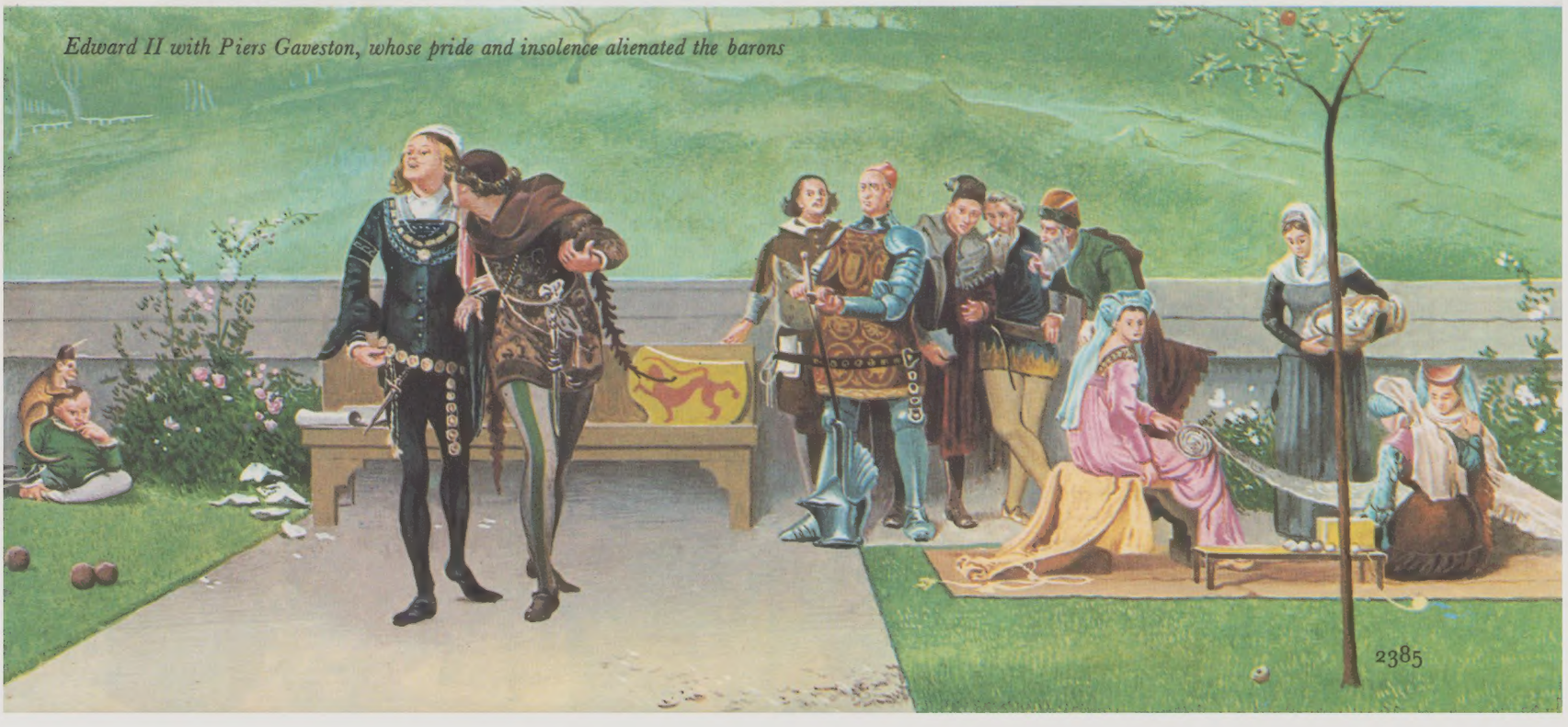
The conflict begins

Magna Carta (see page 374) was the first attempt by the barons to restrict the king by law. But they did not really attempt to interfere with the government. They merely wanted the king to respect their feudal rights and privileges, and not levy 'unlawful' taxes or take 'baronial hostages'.

King John died in 1216, and the new King, Henry III, was a minor. During his minority the barons, as one might expect after their Magna Carta triumph, dominated the government. The important offices were taken by the baronial leaders like Hubert de Burgh, who became Justiciar, and Ralph Neville, who became Chancellor. But gradually the barons found a most disturbing process at work. Without losing their offices they began to lose their power – not to the King, who had not yet asserted his authority, but to a group of the King's household officials led by Peter des Roches and his nephew Peter des Riveaux. They expanded their own offices (Riveaux, for example, was Keeper of the Royal Chamber and the Ward-



One of Edward I's parliaments. The commons sit between the Lords Spiritual and Temporal. Before the King from left to right: the Archbishop of Canterbury, the King of Scotland, the Prince of Wales, and the Papal Legate



Edward II with Piers Gaveston, whose pride and insolence alienated the barons

Edward II is forced to abdicate in favour of his son

robe) so that the Great Offices became less important. The Chancellor lost most of his authority (which was based on his custody of the Great Seal) by des Roches's policy of using the King's personal seal, the *privy seal*. In 1232 the Peters were able to overthrow de Burgh, but their enormous powers alienated the barons, and in 1234 the King dismissed both men and announced that he would now rule by himself.

The Peters had failed, but they had pointed the way the King was to follow. From now on the King would attempt to escape from baronial influence by increasing the power of his household offices and reducing those of the Great Offices of State. The Exchequer and Chancery were fixed and easily accessible to the barons. But the Chamber and Wardrobe were personal and moved about with the King wherever he went. Henry III launched an attack on the state offices soon after his accession to power. He abolished the office of Justiciar and, though he did not remove Neville from the Chancery, he took away the Great Seal and lodged it in the Wardrobe. In 1242 he went abroad and actually took the Great Seal with him – this showed how little he was prepared to share the business of government.

Moreover, the King had begun to place his trust in a group of foreign uncles and nephews, Poitevins and Savoyards, and it seemed that all the King wanted from his barons was money to pay for his rather futile wars in Gascony. The barons thought the King could live on his private means, and resented these taxes. This situation could not continue.

The barons attack

Hostility to the King formed round the great Earls of Leicester (Simon de Montfort, see page 1956) and of Gloucester. In 1258 they struck and demanded the expulsion of all foreigners from the King's government. Then at a parliament at Oxford they imposed a permanent council of 15 to supervise the King. Their main amendments were to make the Great Offices of State independent of the King and the household and raise them to their former stature. For example, the Exchequer, not the Wardrobe, was to receive the revenues of the realm. But the barons could not keep a united front. The two leaders, Gloucester and Leicester, quarrelled incessantly, and in 1261 Henry was able to dismiss the Justiciar and the Chancellor. Although the King managed briefly to assert himself, in 1264 de Montfort won a crushing victory at Lewes, and the King's brother, the mighty Richard of Cornwall, fled the field and locked himself in a windmill. But a final breach between Leicester and Gloucester led to the battle of Evesham the following year, which was a triumph for Henry, and during which de Montfort was killed.

De Montfort failed because he had gone too far. He had tried to replace the power of the King altogether by that of a council. But the majority of the barons were not against the King so long as he shared his government with them, and by 1265 most of them were on his side. Few of the barons really appreciated what was happening – that the old feudal system was dying; and that the increase of the business of government made it necessary to have a trained professional staff of civil servants, largely recruited from the household, who would naturally know more about the business of government than the barons.

Henry's personal rule began again, and for the rest of his reign there was no further trouble. Nor was there much trouble under his son, the great Edward I (1272–1307). His successful campaigns against Scotland and Wales provided rich plunder for the magnates, and though a less successful war against France and heavy taxation in the later years of his reign caused some opposition, his personality was too strong for the barons to think of open rebellion.

A foolish king

But Edward's son, Edward II (1307–1327), was completely different – in fact he was exactly the type of king the barons did not like. He was lazy and extravagant; he hated war and detested the kingly pursuits expected of him. He made favourites of men of humble origin, and in particular a man called Piers Gaveston, who was proud, haughty, and infuriated the magnates by inventing nicknames for them. He called Lancaster 'cherl' and Warwick 'black hound of Arden'. The barons deeply resented the confidence, affection, and rewards the King showered on Gaveston, and the reign was only one year old when they forced Edward to banish him, but he returned only to be banished again. Meanwhile Edward was concentrating his government more and more on his household, and by 1310 a group of leading barons had decided to force him to listen to them. In 1311 they imposed certain *Ordinances* on Edward in which they sought to limit the power of his household, and confirm the banishment of Gaveston. They insisted that all Great Offices, including the Wardrobe, should only be appointed with the consent of the magnates in parliament. In those days both sides used to appeal to the common man by calling parliaments, but in practice parliament meant little more than the king and his greatest nobles. The leaders of these *Lords Ordainers*, as they were called, were Warwick, Arundel, Gloucester, Nottingham, and in particular Thomas of Lancaster, easily the most important baron. The arch-enemy of the Lords Or-

John of Gaunt

dainers soon became their victim. Gaveston did not leave the country, but was captured by Warwick and hanged on Lancaster's estate. The King never forgave this deed. As yet he could do nothing, for the barons were all-powerful. But Lancaster's influence declined after 1317 when he had a violent quarrel with the Earl of Surrey, who carried off his wife.

By 1318 a moderate middle party had grown up. It consisted of Surrey, Norfolk, Hereford, and Hugh Despenser and his son. The younger Despenser was a man of unscrupulous ambition and he ingratiated himself with the King in much the same way as Gaveston. He made a reckless war on the Marcher lords to try to win their territory and was foolishly supported by the King. The barons were once more driven into open revolt, and the forces of Thomas of Lancaster and his followers were gathered. War came in 1322, but the royalists won. At the great battle of Boroughbridge Lancaster himself was captured and executed, and his men scattered.

Edward meets his doom

So Edward resumed his 'personal' rule, and Despenser continued to amass immense wealth and power. Finally in 1327 Roger Mortimer of the Marchers, who had fled abroad and become the lover of Edward's own wife Isabella, returned. The barons flocked to his side. Edward was seized and locked up in Berkeley Castle, where he was brutally murdered a few months later. The barons had killed their first king. But still there was no peace. The new King, Edward III (1327–1377), was a child, and Mortimer and Isabella aroused hostility by their arrogance and enormous power. They broke with Henry, the new Earl of Lancaster. In 1330 the young Edward plotted against Mortimer and had most of the magnates behind him. They rallied to the young King's side when he rose up against the hated Earl. Mortimer was captured and sentenced to death.

Edward III's reign was extraordinarily successful. He was more interested in war than politics. He understood the magnates and they understood him. He sought their advice and took them into his confidence. The early part of his reign saw the first and most successful phase of the Hundred Years War. The war lined the pockets of the magnates, and harmony reigned until the very end of Edward's reign. By then the war had turned against England, and increased taxation upset not only the barons but the commons as well. The King was old and no longer confided in his barons. The magnates encouraged the Speaker of the House of Commons publicly to attack the court party (without mentioning its leader, the mighty John of Gaunt, Duke of Lancaster). In 1376 they impeached (summoned for judgment) the Chamberlain Latimer and the Treasurer Lyons, who were promptly executed. Next year the King died, and another minor, Richard II (1377–1399), succeeded.

The last Plantagenet

Richard's reign was a disaster. Though more able, he had much in common with Edward II. He liked to rule with men chosen by himself, and he hated war. His particular favourites were the son of a merchant called Michael de la Pole and a young nobleman called Robert de Vere. The barons attacked in 1387. A group of them appealed (accused) the King's ministers. At the *Merciless Parliament* of 1388 Pole and de Vere were exiled and other ministers executed. The leaders of the *Lords Appellant* were Arundel, Warwick, Henry Bolingbroke (son of John of Gaunt), Thomas of Woodstock (brother of Gaunt), and Nottingham. The Appellants also imposed a permanent council upon the King in a final attempt to get him to rule with his magnates and without special intimates and 'friends'.

The following year Richard declared himself of age and rid himself of the council. There was no trouble. Tranquillity reigned for eight years; and then in 1397 the King showed all the stupidity, violence, and revenge of which he was capable. He accused Warwick, Arundel, and Woodstock of conspiring against him and promised that no harm would come to them if they surrendered for judgment. He had Woodstock murdered, executed Arundel, and imprisoned Warwick for life. The following year he acted with the grossest stupidity in a quarrel between the remaining Appellants, Bolingbroke and Nottingham (now Norfolk). He exiled them both, and when in 1399 John of Gaunt died and the inheritance of Lancaster fell to Bolingbroke, Richard confiscated the estate. Bolingbroke had practically the whole country behind him when he landed to claim his rights. Richard was seized, forced to abdicate, and died shortly afterwards in Pontefract Castle.

The wheel had turned full circle. It began with the barons wanting to share the government; it ended by their most powerful member, Lancaster, seizing it.

The Plantagenet dynasty ends. Richard II resigns the crown to the Lancastrian Henry Bolingbroke

The geographical position of the main Belgian cities

Ghent: the great 12th-century castle

Bruges: the famous 13th-century belfry

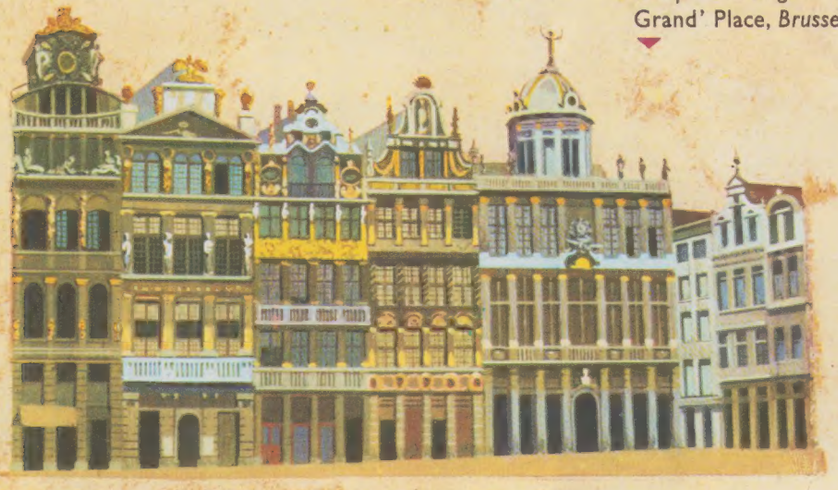
The Hôtel de Ville in Brussels; its high spire is crowned with a statue of St Michael

'THE cockpit of Europe' – this name for Belgium is well-deserved. For centuries armies have fought over and plundered this small country. Yet the cities of Belgium have maintained their prosperity. Why? First because these cities are in a position of commercial as well as strategic importance, with outlets to the North Sea, and connected by canals with the great rivers of France and Germany; secondly because of the natural resources of Belgium on which many of her great industries are based; and thirdly because Belgium has now joined the European Economic Community, or Common Market.

BRUSSELS

Brussels, the capital of Belgium, lies in the centre of the Plain of Brabant (see page 2380); the name means 'settlement in the marshes'. It grew up in the Middle Ages at the point where the river Senne ceased to be navigable, and was crossed by the main land route between Flanders and the Rhineland. The earliest settlement was on the Île Saint-Géry, a fortified island, and gradually the town spread on to the east bank of the river. It is roughly divided into two: the 'lower town', the main commercial centre, and the 'upper town' built on higher ground farther to the east, the site of the *Palais de la Nation* (the Parliament House), the Royal Palace, and the immense *Palais de Justice*, built between 1866 and 1883 in the Ancient Egyptian style.

Some of the magnificent Baroque buildings in the Grand' Place, Brussels



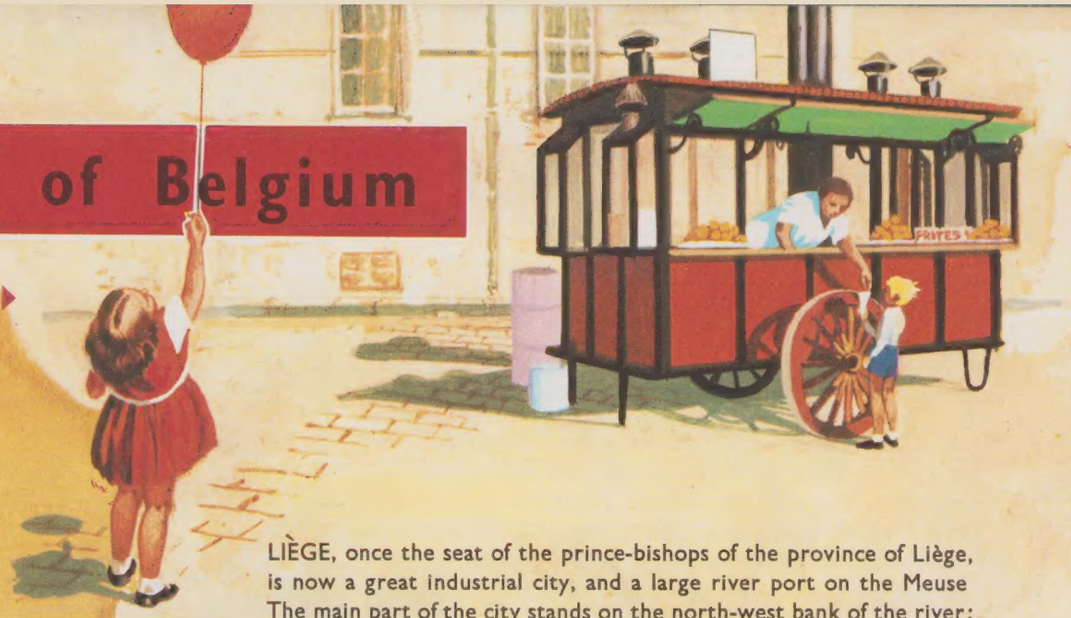
Most of the older parts of the city have vanished under 19th- and 20th-century buildings and boulevards, but the *Grand' Place*, in the lower town, is still unspoilt. Its lovely buildings, ornately carved and gilded, face each other across a flower market; on the south side is the *Hôtel de Ville* (City Hall), which was built between 1402 and 1454 and has a tower over 350 feet high, while on the other sides are the 17th-century halls of the old trade guilds.

Cities of Belgium

The port of Antwerp on the Scheldt

An aerial view of the Meuse at Liège

Belgians, like the English, love potato chips, and sellers like the woman on the right are a characteristic sight



Today Brussels has become a cosmopolitan city, and the administrative centre of the European Economic Community. The river Senne has been covered over, and carries the central boulevards which link the two great stations in the north-east and south-west of the city. Industries including food-processing, tobacco, chemicals, and engineering have grown up, and factories have spread for miles around.

ANTWERP

Antwerp is Belgium's biggest seaport and one of the greatest commercial harbours in Europe. It lies on the river Scheldt, about 58 miles from the sea, and an old local proverb says: 'Antwerp owes the Scheldt to God and everything else to the Scheldt.' It is certainly its position on this great river that led to its prosperity in the first half of the 16th century, when it became the greatest trading and banking centre in Europe. This was partly due to the deepening of the West Scheldt river and the silting up of the river Zwin at Bruges which caused foreign merchants to move to Antwerp, and partly due to its freedom from guild restrictions. For about 50 years Antwerp, the financial heart of the great Spanish Empire, was enormously prosperous. But a slump in its vital cloth trade in the mid-16th century, followed by the revolt of the Low Countries against Spain, ended this prosperity. In the 'Spanish Fury' of 1576 the city was sacked, while the siege of 1584 to 1585 caused still more damage. Finally in 1648 the Scheldt was closed to commercial shipping by the Treaty of Münster.

Antwerp's international importance seemed over, until Napoleon decided to make it his empire's chief military harbour and poured millions of francs into new equipment, wharves, and docks. It is now one of the four largest ports in Europe, and is linked by canals to France, Holland, and the Rhineland. It also has a flourishing diamond industry.

LIÈGE, once the seat of the prince-bishops of the province of Liège, is now a great industrial city, and a large river port on the Meuse The main part of the city stands on the north-west bank of the river; the other bank is lined with factories and the homes of factory workers. The nearby deposits of coal, limestone, and iron-ore, and the transport provided by the Meuse, led to the development of the iron and steel industry and the manufacture of small arms. Other very important industries are the production of zinc and engineering.

Despite this modern development the city still has some lovely mediaeval buildings, among them the cathedral of St Paul (1280–1528) and the 10th-century church of St Denis.

CHARLEROI, sometimes called 'Black Charleroi', is an industrial town on the river Sambre, a tributary of the Moselle, about 30 miles south of Brussels. With the development of the Sambre-Meuse coalfield in the 19th century it became the centre of an important mining and manufacturing area.

OSTEND, on the Belgian coast, is the country's largest fishing port. By the 15th century it had a packet-boat service to London, and now it has a daily ferry service to and from Dover. It is the starting-point of several trans-European railways, and is connected to Brussels by a high-speed motorway. It is now a popular seaside resort.

One of the longest and most famous sieges in history was that of Ostend by the Spaniards from July 1601 to September 1604.

GHENT, like Antwerp, lies on the river Scheldt. It grew up in the 12th century, and by the 13th century was one of the largest towns in northern Europe. This was largely due to its trade in luxury cloths woven there from English wool, which were famous until the 15th century. John of Gaunt was born there, and so was the Emperor Charles V 160 years later.

Ghent's prosperity gave it considerable political power, but uprisings against the counts of Flanders in the 14th century and the dukes of Burgundy in the 15th century, a revolt against Charles V in 1540, and the slump in the wool trade, all led to its decline. But in the early 19th century cotton spinning was introduced, and today Ghent is the centre of the Belgian textile industry, and an important port.

BRUGES takes its name from the many bridges crossing the network of canals running through it (the Flemish name for Bruges, *Brugge*, means bridge). It lies only 7 miles from the North Sea. In the Middle Ages it was a great wool town, and (unlike so many old towns) there has been little later building to change its character. Its quiet canals, bordered by old buildings and trees, twist in and out. The 16th-century market hall incorporates a 13th-century belfry with a *carillon* of 47 bells, and there are many other lovely mediaeval (and Renaissance) buildings.

THE TIGER

1877: 919 men	.	.	.	.	1,579 tigers
1878: 816 men	.	.	.	.	1,493 tigers
1883: 985 men	.	.	.	.	1,726 tigers
1886: 928 men	.	.	.	.	1,464 tigers

THESE figures are taken from the records of the Government of India during the last century; they show the number of men recorded as having been killed by tigers, and the number of tigers known to have been killed by man. A. R. Wallace, the English naturalist and explorer, wrote of his visit to the island of Singapore in the 1850's that: 'There are always a few tigers roaming about Singapore and they kill on an average a man every day, principally those who work in the gambir plantations, which are always made in newly-cleared jungle.' Even in recent years workers on rubber estates in Malaya have occasionally been taken by tigers, usually when they start work at sunrise.

This all goes to show that tigers can be very dangerous beasts and, if they are numerous, a real menace to human life. The figures from India show another thing: that nearly a hundred years ago the tigers were fighting an unequal battle. There were far more men in India than tigers, but more tigers than men were killed. In common with so many of the larger wild animals, tigers are now much reduced in numbers, and there are few places where anyone need go in fear of them.

It is true that there are 'man-eating' tigers, beasts that seem to prefer human prey. Just what goes to make a man-eater no one really knows. The idea that they are all old tigers, too slow and blunt of tooth and claw to hunt, is not true. It is more likely to be a matter of chance. A tiger, pressed by hunger, will overcome his fear of man and kill one, and so discover what a helpless creature a man is when he is unarmed. Such a tiger will usually not bother with other prey. But with modern firearms against him the career of a man-eating tiger is likely to be short.

A professional hunter kills a tiger which has been terrorising the district; the

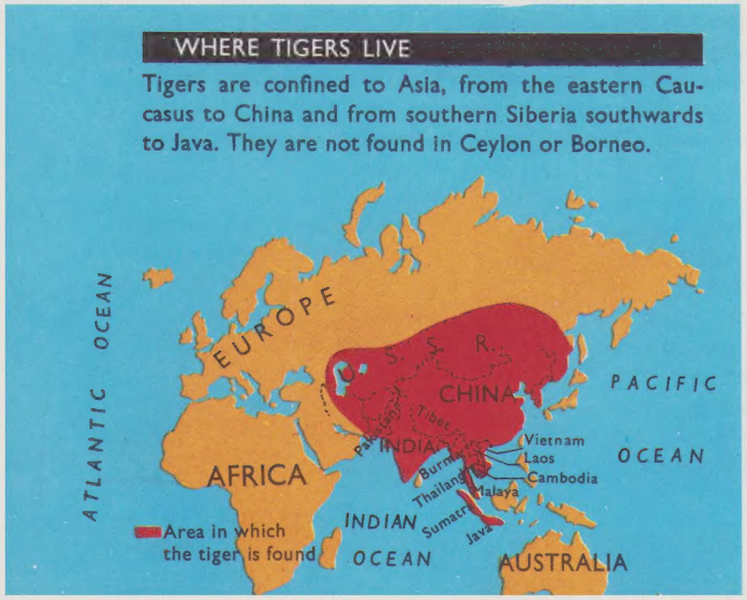
Hunting the tiger

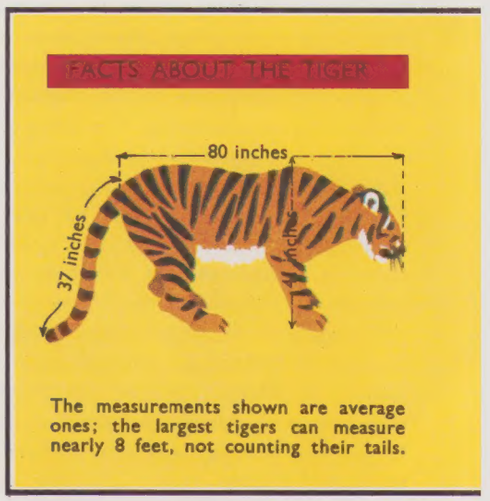
To the wealthy rajahs of the Indian states tiger hunting was the finest sport that they could enjoy themselves or offer to distinguished guests. It was done in a most ceremonious and exciting way. First, a week or more in advance, professional hunters or shikaris located a tiger in an area of jungle and kept a watch on it to make sure that it could be found on the day appointed for the hunt.

When the day came the rajah and his guests, armed with rifles, would mount their elephants. Meanwhile a large number of men, acting as 'beaters', would partly surround the area pointed out by the shikaris. They would then advance, making a tremendous noise with gongs and drums so as to drive the tiger towards the elephants. All animals, however formidable, are frightened of a noisy army of men, and the tiger would seldom turn back and break through the line of beaters. As it is not easy to shoot accurately from the back of an elephant, the tiger was often wounded and put up a fight. However, the elephants could well defend themselves with their tusks and fore-feet, and really the tiger had no chance.

The professional hunter

Far more tigers, however, are killed in a much less spectacular manner. If a tiger makes a nuisance of itself by killing domestic animals, a hunter is called in. Either he will find an animal freshly killed by the tiger, to which it is likely to return for another meal, or he will tie a goat to a tree or a stake. He then climbs a nearby tree and waits, from dusk until dawn, for the tiger to come. If it arrives when there is enough light to see clearly it is easy for him to shoot it.




FACTS ABOUT THE TIGER
80 inches
37 inches
The measurements shown are average ones; the largest tigers can measure nearly 8 feet, not counting their tails.

tiger, lured by the tethered goat, passes beneath the hunter's tree and presents an easy target

The largest tigers are found in snowy regions

Tigers are by no means confined to countries with a hot climate, but extend northwards into China and southern Siberia. In fact the largest tigers are found in regions where the winter brings ice and snow.

They are good swimmers and take to the water more readily than any other cats.

TIGER AND LION

In size the two great cats are very close, but the largest tigers are bigger than the largest lions, so the tiger must be accounted the bigger animal. They differ considerably in habits, the tiger being mainly a forest animal, while lions inhabit savannah and semi-desert country. The tiger is a solitary beast. The cubs stay with their mother only as long as it takes them to learn to hunt; tigers never go about in family parties as lions do. Tigers are less easily tamed than lions, and this is possibly due to their unsociable nature. Baby tiger cubs can be reared by hand, but when they approach full size they are always dangerous.

A fairly big tiger weighs about 450 pounds.

A tiger can leap a distance of 15 to 20 feet.

Although tigers do not climb trees, they are able to jump into the lower branches in a single bound

A tiger can eat 70 or 80 pounds of meat at a single meal.

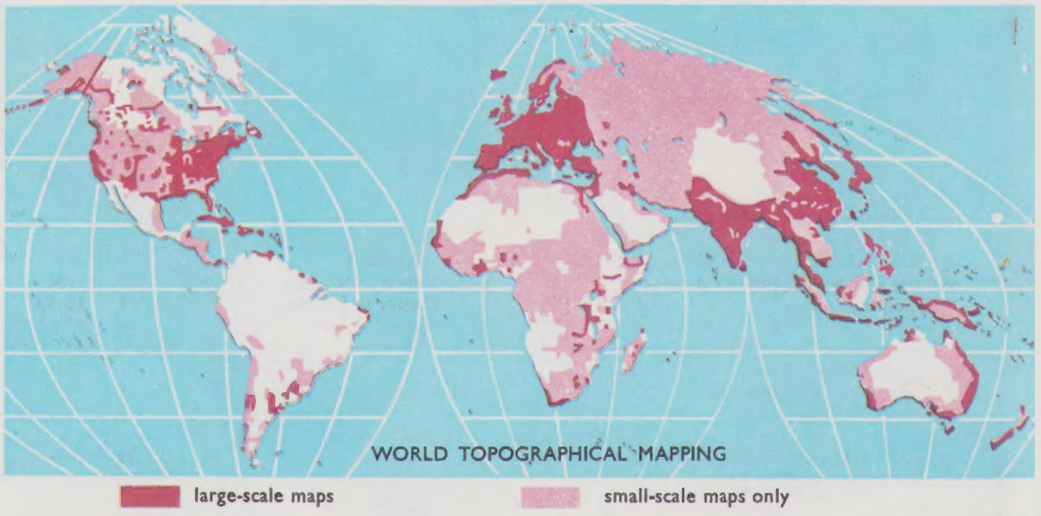
The roar of a tiger sounds rather like the syllables 'oo-ung'. When it is frightened or angry it makes short coughing roars.

In captivity tigers have been known to live 20 years.

CARTOGRAPHY

THE map of the world on the right shows the present-day extent of the cover of *topographical maps* (scale $\frac{1}{4}$ inch to 1 mile or larger). Such maps show the details of the country with some accuracy and are therefore necessary for both planning and scientific work. The map shows that there are still large areas of the world, especially in South America, for which there are no topographical maps. A large part of the remainder has been mapped only at small scales, or else the work is old and inferior in quality.

Since maps are so important to sensible development of natural resources and good administration, it is remarkable and regrettable that less than one-quarter of the land areas of the world are provided with modern large-scale topographical maps. It is, however, important to realise that the whole work of making these maps (which is the modern definition of *cartography*) is a slow and complex business. It is made up of several distinct phases: first, the creation of a *control survey* by men working on the ground; secondly, *aerial photography* of the entire country; thirdly, the *compilation*, *drawing*, and *reproduction* of the map sheet from the information provided by the first two phases.



Map of Britain showing the control points used by the Ordnance Survey for all mapping

Control survey

In surveying it is necessary 'to work from the whole to the part'. In other words the surveyor must locate the positions of a few widely-spaced places with great accuracy and then fill in the intervening *detail* of roads, rivers, railways, houses, and hills with reference to these *control points*. The preliminary stage in mapping is therefore the determination of the distances between the points, and the accurate location of some of the points by astronomical methods. It is usual for the control points to be situated at the vertices of a system of interlocking triangles with sides of length 5 to 100 miles. Much of the work of triangulation consists of the measurement of the angles in each triangle by theodolite.

Until recently the lengths of only one or two sides of the triangulation system were measured, and the lengths of the other sides were calculated by trigonometry. This was because the measurement had to be made with a steel tape, which was a very slow process. Nowadays, however, accurate measurements of 50 miles or more can be made by a *tellurometer*. This instrument measures the time taken for a radio wave to pass between two control points, and enables the work to be carried out in a few minutes; so it is now practical to measure the lengths of all sides in the triangulation system.

Aerial photography

The control survey only establishes the positions of the points where the observations have been made, and can show nothing of the intervening ground detail which must be plotted on the map. This information is obtained by photographing the country from an aircraft using a camera which points vertically downwards.

It is not enough to obtain complete photographic cover of the area which is to be mapped. The plotting instrument makes use of a *stereoscopic* (or 3D) *model*, and, to get this, each part of the country must be photographed at least twice, from different places.

The best way of obtaining the necessary pictures is to take a series of

The aircraft flies straight while the camera takes photographs at fixed intervals

photographs with about 60 per cent of overlap between each photograph in the direction of flight. One flight will therefore produce a strip of overlapping photographs of the country, and the aircraft must be flown to and fro along a series of parallel tracks until the whole area has been covered. Although the vertical aerial photograph looks rather like a map, it cannot yet be used for making accurate measurements. The photograph possesses certain inevitable distortions, and in addition there may be other inaccuracies which result from tilting of the aircraft in flight. Much additional work must be done before the photographs can be converted into an accurate map.

Plotting, compilation, and drawing

Each pair of photographs must now be placed in a *photogrammetric plotter*, which is used to view the photographs, make adjustments for any tilting which occurred, measure ground height, and plot the required map detail. The scale for plotting is obtained by the comparison of the distances between the control points shown on the photographs and the known distances between the same points determined by the ground survey. Thus mapping from aerial photographs is still dependent upon the measurements of ground survey. The plotter contains a small measuring mark which can be moved about the stereoscopic model by the operator as he looks at it, and these movements are transferred mechanically to a *co-ordinatograph* or drawing table over which a plotting pencil is driven. To draw the outline of a road, for example, the operator moves the mark along his view of the road and the pencil automatically draws it at the required scale. The next stage is the compilation or assembly of each plot into a single map; a typical topographical map of scale 1 inch to 1 mile may be based on 100 or more such plots. The assembled map will now be photographed, in order to make several identical copies of it, since a coloured map must be printed one colour at a time, and therefore the details to be shown in different colours must be separated from one another. The prints are made on either glass or plastic which has a special opaque coating.

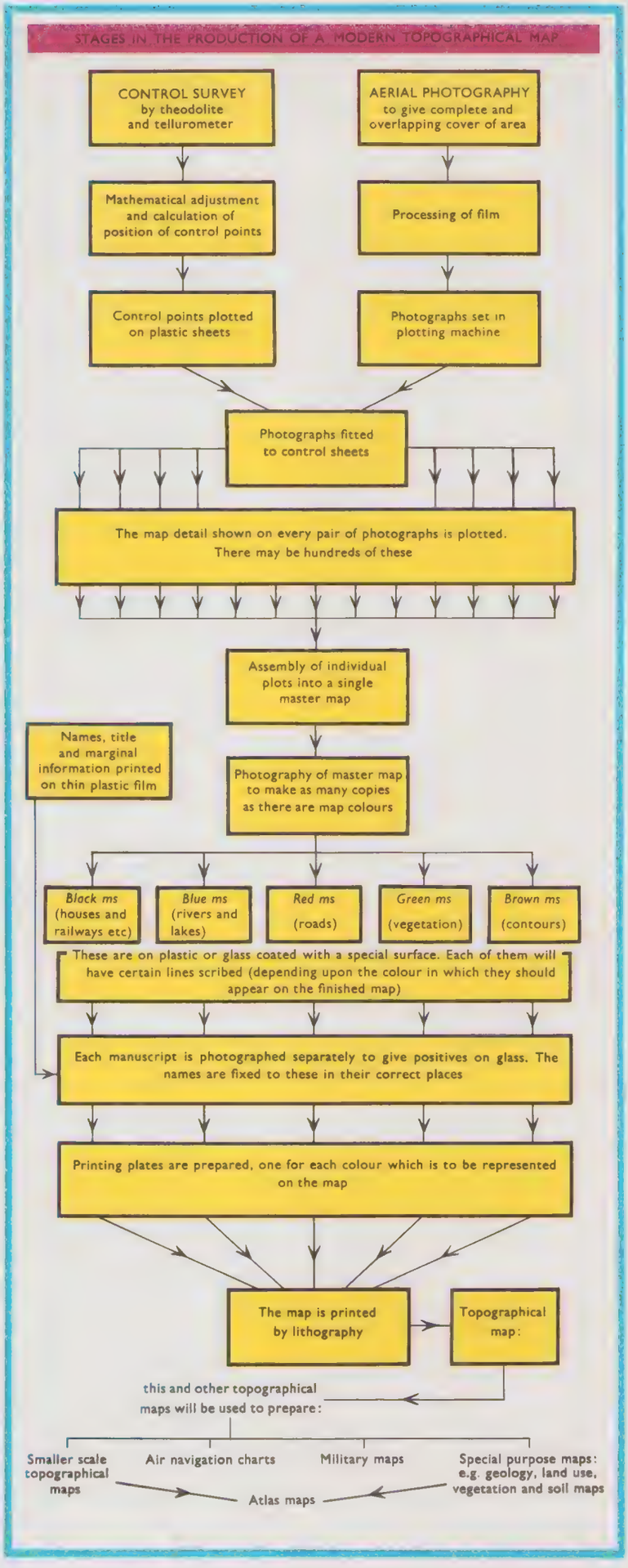
Map drawing nowadays is done by *negative scribing*, or cutting into the coating with a sharp steel or sapphire tool. This leaves a stencil of clear lines and symbols on an opaque background.

Lettering and the addition of *ornament* (patterns for woodland and so on) is done by printing the names and patterns on thin transparent plastic which is cut out and stuck to positive copies made from the scribed drawings. Hand lettering by ink has now almost disappeared.

Reproduction

The individual drawings now pass through a series of photographic and chemical processes to reproduce the map image on metal printing plates. These are set in a lithographic printing press, and the map is printed on paper, one colour at a time.

Small-scale topographical maps, atlas maps, and special maps will eventually be made using this topographical map as the source. The work from compilation onwards is the same as described here, because the new maps will almost certainly have to be redrawn. This is because it is impossible to show all the details included on a topographical map at the much smaller scale of an atlas map of the same region. The smaller the scale, the greater is the *generalisation* of the information which can be shown if the map is to remain clear and legible.


STAGES IN THE PRODUCTION OF A MODERN TOPOGRAPHICAL MAP
CONTROL SURVEY by theodolite and tellurometer
AERIAL PHOTOGRAPHY to give complete and overlapping cover of area
Mathematical adjustment and calculation of position of control points
Processing of film
Control points plotted on plastic sheets
Photographs set in plotting machine
Photographs fitted to control sheets
The map detail shown on every pair of photographs is plotted. There may be hundreds of these
Assembly of individual plots into a single master map
Names, title and marginal information printed on thin plastic film
Photography of master map to make as many copies as there are map colours
Black ms (houses and railways etc)
Blue ms (rivers and lakes)
Red ms (roads)
Green ms (vegetation)
Brown ms (contours)
These are on plastic or glass coated with a special surface. Each of them will have certain lines scribed (depending upon the colour in which they should appear on the finished map)
Each manuscript is photographed separately to give positives on glass. The names are fixed to these in their correct places
Printing plates are prepared, one for each colour which is to be represented on the map
The map is printed by lithography
Topographical map:
this and other topographical maps will be used to prepare:
Smaller scale topographical maps
Air navigation charts
Military maps
Special purpose maps: e.g. geology, land use, vegetation and soil maps
Atlas maps

ATHENS: the first democracy

DEMOCRACY is not a modern invention. It comes from two Greek words meaning 'rule of the people', and the first democracy was set up in Athens over 400 years B C.

The great Athenian Aristotle (see page 1222) wrote: 'The most pure democracy is that which is so called principally from that equality which prevails in it . . . the law of that state directs that the poor shall be in no greater subjection than the rich; nor that the supreme power shall be lodged with either of these, but that both shall share it.'

Athens is the capital of modern Greece. In ancient times it was the capital of the region Attica. Attica was among the first unified states of Greece and was strong enough to resist the invasion of the Dorian people who established themselves over much of Greece in about 1000 B C. Originally the Athenian state was a monarchy, but little is known about her kings. By the early 7th century B C she had become a republic, but by this time she had already been outstripped both in power and culture by the more dynamic Dorian states like Corinth and Sparta.

The reason for Athens' weakness was her constitution. In contrast to other Greek city-states power rested largely with the individual tribes of Attica. They were strong while the state was weak. Each tribe and clan was a state within a state, with its own courts and religious rites. Bringing Athens under a central control and broadening the base of this control so that it rested on the people as a whole was the work of the great legislators Solon, Cleisthenes, Ephialtes, and Pericles. Let us now follow Athens on the road from the rule of the few to the rule of many – from oligarchy to democracy.

Inequalities in ancient Athens

The population of Attica originally consisted of four tribes, and each was subdivided into three 'brotherhoods' or *phratries*. The land occupied by each phratry was called a *trittys* or third.

The members of the phratry consisted of two groups – those who were members of *clans* and those who were members of *guilds*. The clans owned and worked the land while the guilds practised trade and handicrafts. The clan was a large tribal unit made up of many families. The land occupied by the clans was *inalienable* – that is, it could not be taken away.

Clans were the racial élite. Within each phratry it was the leading clansmen not the guildsmen who conducted the administration of religion and law, and the admission of new members when they came of age. Certainly the majority of Athenians felt themselves governed more by their clans than by the state.

What then of the institutions of the state? After the fall of the kingship, the duties of the king were carried on by three annually elected *archons*; his religious duties by the king-magistrate (*archon basileus*), his military duties by the military magistrate (*polemarchos*), and his civil duties by the *Eponymous Archon*. In time six 'recorders', or junior archons, were created (see page 512).

After finishing their year in office the archons became life members of the *Council* which sat on the Areopagus Hill. This Council was in fact the hub of the constitution which supervised the archons and conducted state affairs.

There was also the *Assembly* of all the citizens. This elected the archons and therefore ultimately chose the members of the Areopagus Council. Yet qualifications for the archonships were defined as 'birth and wealth' – this meant the wealthy clansmen and excluded members of the guilds. Moreover, the most powerful clans could act as 'pressure groups' in the Assembly to get their own men into office.

To sum up so far, the Council was aristocratic. The rights of the people were limited, and there were important inequalities between clansmen and guildsmen. Above all, while the power of the clans remained intact there was no common state law for every citizen. Athens had still a long way to go before she could be a democracy.

Dramatic climax

In 621 B C Draco was appointed to draw up a legal code. He increased the power of the state by setting up a Court of Appeal to hear appeals in cases of bloodshed. It had 51 judges elected on a 'birth' qualification (that is, only clansmen). But prosecution of all cases and indeed the great bulk of the law was still in the hands of the individual tribes.

The reforms of Solon

Solon was appointed 'reformer of the Constitution' in the year 592–591. His reforms set Athens on the path to a more efficient and 'democratic' constitution (see page 512). He changed the qualifications for the archonships from 'birth and wealth' to 'wealth'. The Athenian population was traditionally divided into two economic classes: the wealthy *cavalrymen* and the poorer *men of the line*. To these Solon added two more: the extremely wealthy *500 Bushellers* and the extremely poor *labourers*. The new first class (the 500 Bushellers) he made eligible for the main office of state treasurer. The first and second were eligible for archonships; the first, second, and third, for minor offices; and the labourers were ineligible for office. Solon's Athens was thus an aristocracy of wealth rather than of birth.

The election of magistrates remained the same – the straight majority vote in the Assembly – but Solon also instituted a right

of the struggle for democracy; Hipparchus, one of the sons of Peisistratus, is set upon by two young Athenians

of appeal against any edict of the magistrates before a special people's court, the *Heliaea*. Later this court came to audit the archons' acts, and so the principle was established that the magistrates were responsible to the people as a whole. Alongside the Council Solon instituted a special 'Council of 400' which represented each of four tribes and had to prepare and advise on business that went before the Assembly.

Solon's reforms did not damage the power of the clans, nor did they result in the submission of the Areopagus Council to control by the people. Even so, Solon's reforms were too radical for the powerful clans to stomach, and civil war broke out. The chaos ended only in 546 when Peisistratus, an Athenian nobleman, succeeded in storming the Acropolis and establishing himself as a 'tyrant'.

Peisistratus' rule, and that of his sons which followed, was extraordinarily successful. He was indulgent to the lower classes, and when his sons were overthrown in 510 Athens had undergone 36 formative years: the small man had become very important; immigrant craftsmen had swelled the guilds; while the clans, whose leading members had been in exile, had lost much influence.

The time was ripe for further reform, and in 508 a nobleman called Cleisthenes (who had been in exile) undertook the unenviable task of reducing the predominant influence of the clans. Real reform could only come by breaking down the powerful landed interest of the clans, and so Cleisthenes parcelled out the land of the state in a totally different way. He divided Attica into about 170 small units called *demes*, and to foster a corporate spirit, membership was made hereditary. When voting, a man merely registered himself as a member of a deme, and so the distinction between clans and guilds disappeared.

Cleisthenes also divided Attica into three regions – Athens the capital, the coastal region, and the interior. Then he grouped the demes of each of these areas into 10 separate units called *trittyes*. But the demes comprising each trittys were not next to each other, so that a trittys ceased to be a continuous piece of land. Then, by lots, Cleisthenes chose one trittys from each region and called the three together a *tribe*. Thus he was able to create 10 tribes based neither on hereditary landed wealth nor distinction of birth. The old racial tribal system was ended.

Cleisthenes replaced the Council of 400 by a Council of 500 (with much the same functions). Each of his tribes selected 50 members chosen by lot from a much larger batch elected by the demes. The effect of Cleisthenes' reforms was that every Athenian had an equal right in voting free from the pressure groups formerly provided by the clans.

As before, the most powerful element of the constitution was the Areopagus Council. Its members came from ex-archons who still came only from the top two income groups. The archons were nearly always aristocrats. But the Council of 500 was not aristocratic, and the ordinary people rapidly gained administrative experience which was to play an important part in the final chapter on the road to a democracy (*demokratia*) and the rule of the people (*demos*).

The rule of the people

Gradually the Council of Areopagus lost its prestige. In 487 the archons were selected not by direct election but by lot from an original election of 500. In 462 Ephialtes and Pericles carried through a democratic reform of the constitution.

The Areopagus Council was stripped of its political powers which were divided between the Council of 500 and the Assembly. The 500 acquired the right to supervise the magistrates and became the chief executive organ of the state. Most legal functions of the Council went to the People's Court of the Heliaea.

All officials were now responsible to those who had elected them – that is everybody, irrespective of birth or wealth.

NYLON

UNTIL the middle of the last century natural fibres – cotton, wool, silk, and hair – were the only raw materials used for making textiles. Then chemists discovered that they could make artificial silk, or rayon, by treating cellulose from plants with certain chemicals (see pages 1214–1215). Rayon went into production and became very popular, but the chemists continued their research.

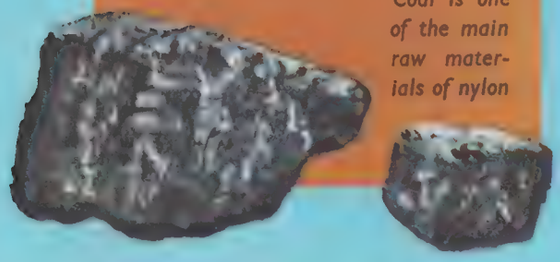
In the late 1920s a research group from the American company E. I. du Pont de Nemours, headed by Dr Wallace Carothers, was concentrating on producing synthetic fibres. The result was the announcement in October 1938 of the discovery of nylon, a generic term for a whole family of synthetic fibres. In December 1939 commercial production was started in America.

Nylon was the first real *synthetic* fibre – that is, made completely from chemicals without using any natural cellulose. Nylon is a protein fibre, with the same general composition as silk or hair, but artificially prepared.

An advantage of all synthetic fibres is that they can be made whenever and wherever they are needed; their production can be regulated and is not affected by bad weather, blight, or any of the other difficulties that may hinder the growth of natural fibres.

WHERE NYLON COMES FROM

Nylon can be made from coal, petroleum, natural gas, furfural (corn cobs, oat husks, and other agricultural by-products), air, and water. Chemicals extracted from these raw materials are mixed together in water, then heated in an autoclave, a sort of pressure-cooker, until all the water is driven off. The molecules (see page 564) of the chemicals are then forced together and join up end to end rather like a chain of paper clips. The sticky mass thus produced is a linear polymeric amide – better known as nylon.



Coal is one of the main raw materials of nylon

HOW NYLON THREADS ARE FORMED

The molten nylon is pulled out into long ribbon-like strands on to a cool roller. When they have hardened, the ribbons are broken up into small chips and mixed with chips from other batches. The chips are then melted again, and turned into threads by a process known as 'melt-spinning': the molten nylon is forced through the tiny holes of a spinnaret (see page 1215) and air-cooled to form solid filaments. These filaments are wound on to a 'cake' and then stretched between a system of rollers revolving at different speeds. This increases the strength and elasticity; for when nylon is stretched, each molecule in the chain becomes longer, leaving the vulnerable joins between them farther apart and making a break less likely.

The filaments are spun into threads of different thicknesses: single or mono-filament yarn for stockings and sheer woven and knitted fabrics; many or multi-filament yarn for clothes and mixing with natural fibres; and staple for heavier fabrics.

PROPERTIES OF NYLON

The principal properties of nylon are its great strength and elasticity; nylon is unaffected by cold or damp, and is not corroded by either the sea or by chemical action. Nylon is easily moulded or pressed into shape, and a vast quantity of nylon is used in industry for pipes, ball joints, and so on, where strength and resistance to wear are vitally important.

SOME EVERYDAY USES OF NYLON

During the Second World War silk was [illegible] for the manufacture of parachutes. [illegible] was found to be a suitable substitute and was put on sale in May 1940, and were instantly in great demand everywhere. Parachute canopies were also made of nylon instead of the usual silk.

Since then nylon by itself, or mixed with natural fibres, has been knitted or woven to make all kinds of clothing, upholstery, carpets, typewriter ribbons, watch-straps, brushes of all kinds, 'cat-gut' for musical instruments and tennis rackets, umbrellas, and the sails and rigging of yachts. Nylon acts as a most effective insulator when poured in a molten state over electric wires and left to harden.

Nylon rope is used for mountaineering, sailing, and trawling, because it is twice as strong as high-grade manila and flexible even when wet or partly frozen.

ANOTHER TYPE OF NYLON

Perlon, made on the continent of Europe since 1938, was the result of combined American and German research. Not as strong as nylon, it is made mainly as staple for heavier fabrics.

A view of Lake Constance in Switzerland, covered by a layer of pollen blown from the surrounding conifer forests

POLLINATION BY WIND AND WATER

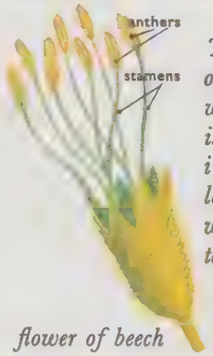
EVERY spring the people who live on the shores of Lake Constance see a curious thing happen: the lake, which is on the northern Swiss border, changes colour, due to a thick layer of fine yellow dust floating on the surface. The people call it 'the blooming of the lake'.

As a matter of fact this picturesque phrase is not far from the truth of the matter. The dusty layer consists of countless millions of tiny grains of pollen from the flowers of the thick pine and fir forests which surround the lake. The pollen is carried far and wide by the wind and eventually settles on the surface of the water.

These coniferous trees (pines and firs) are among the plants whose pollen is carried by the wind. The botanical term for this is *anemophilous pollination*. The word pollination means the conveying of pollen-grains from one flower to another to effect fertilisation, which is necessary for the setting of seed (see page 60); anemophilous means wind-loving. In this article we are not only concerned with this type of pollination but also with the much less common type called *hydrophilous* pollination in which the pollen grains are carried by water.

Small inconspicuous flowers

On page 284 we saw that flowers which are pollinated by insects are often large, brightly coloured, and strongly scented. These features are necessary to attract the insects which will carry their pollen. In wind-pollinated plants such characteristics are obviously not necessary, and they have small, inconspicuous flowers, often green like the leaves around them, and scentless. The stems of the stamens are often long and flexible, so that the anthers project or hang well out of the flower and shake in the slightest wind, shedding their pollen. In some cases the whole inflorescence hangs down, so that it swings and shakes in the breeze; the hazel catkin is an inflorescence of this kind. In wind-pollinated plants the stigmas (the part of the carpel which receives the pollen grains) are usually branched or feathery, so that they trap any grain of pollen that happens to blow up against them.

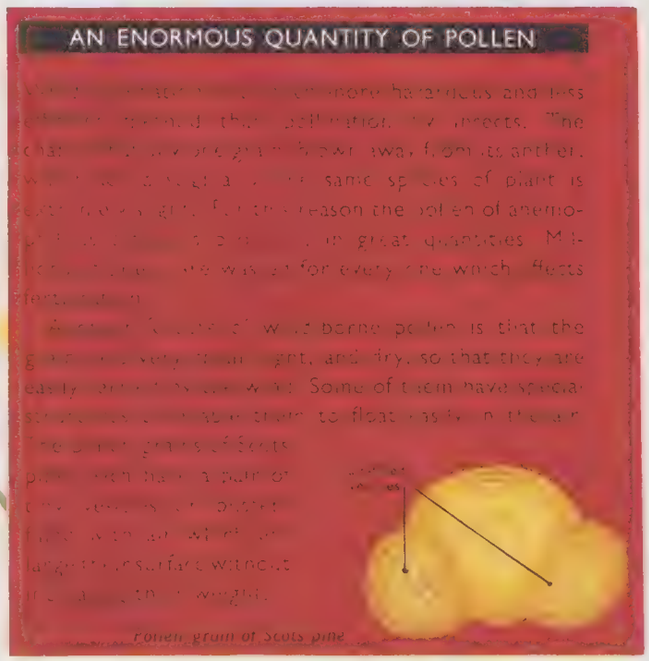


flower of beech

The bright colours of a pansy, whose function is to attract insects, are lacking in the wind-pollinated flower of beech

pansy flower

The flowers of the oat (Avena sativa) *are well adapted to pollination by the wind. Note the characteristic projecting anthers and feathered stigmas*



FIR

BEECH

CHESTNUT

POPLAR

Panoramic view of a forest composed of poplar, chestnut, beech, and fir, all of which are wind-

Examples of wind pollination

Among the well-known plants which are wind-pollinated are the Graminaceae (grasses and cereals such as wheat and oats), nettles, and most of the common trees such as oak, beech, birch, hazel, sweet chestnut, poplars, and all the conifers.

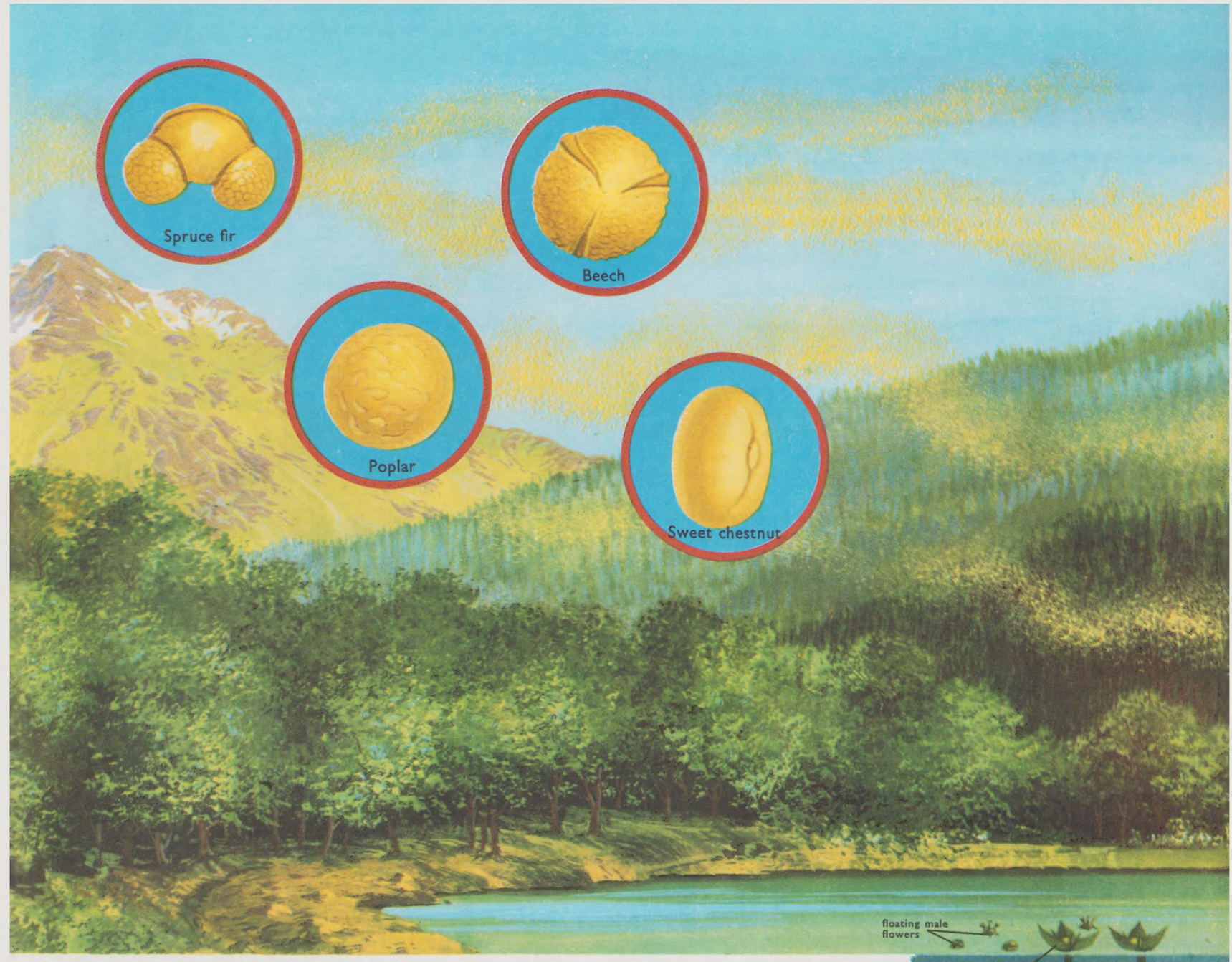
Most wind-pollinated trees bear their flowers right at the ends of the branches. In this way the wind can blow onto the flowers without being obstructed by the leaves, and pollen is blown away from the anthers and arrives easily on the stigmas.

In some trees, such as poplars, elms, and hazels, the flowers develop in the early spring before the leaves appear. This enables the pollen to blow about freely among the branches without any obstruction.

The nettle is a herbaceous plant with wind pollination. Its flowers are small and green. When the pollen is ripe the stamens, which are curved inwards, spring up with a jerk and at the same time the anthers open, throwing the pollen into the air.

Sweet chestnut tree in flower. As in many trees that are wind-pollinated, the flowers are at the ends of the outermost branches

Poplar tree in flower. In this tree the flowers bloom in early spring, before the leaves appear



pollinated. In the circles are single pollen grains, greatly enlarged, of these four kinds of tree

Fossil pollen

A very remarkable thing about pollen grains is that they are extremely resistant to decay. Also the pollen of any kind of plant can be recognised and identified. These two facts enable scientists to use pollen in the study of past climates, because it is preserved in accumulations of sediment or peat even when these are many thousands of years old.

The variations of climate since the end of the Ice Age have been worked out in detail by this means, mainly by examining the pollen grains preserved in successive layers of peat on moors. When only birch pollen is found this indicates that the climate was very cold, only a little less severe than that of the treeless tundra. Scots pine pollen is a sign of rather warmer conditions, while elm, oak, and alder indicate a temperate climate.

Water-borne pollen

A few water plants have special adaptations for pollination. The tape grass (*Vallisneria spiralis*) has male and female flowers on separate plants. The female flowers rise above the surface and open, exposing the stigmas. The male flowers develop under the water; when they are fully formed they break off and rise to the surface, where they float about like little boats. Pollination occurs when they bump against the female flowers. After fertilisation these close and their stems twist into a spiral, drawing them under water.

The marine plant *Zostera* or eel-grass gives an example of pollination under water. Here the pollen has the form of fine threads, not of grains, and its specific gravity is exactly that of water, so that it floats at any depth without rising or sinking.

Pollination of Vallisneria spiralis

PITT THE YOUNGER

WILLIAM PITT, second son of William Pitt, Earl of Chatham (see page 2228), was Chancellor of the Exchequer at the age of 23 and Prime Minister of Great Britain at 24. If he had done nothing else this extraordinary achievement would have earned him a permanent place in our history books. But in fact he proved to be one of the ablest ministers who have ever led the British nation.

How could such a young man come to hold such high offices? To understand this we must not only remember his astonishing ability and his famous name but also two facts about 18th-century politics: first, that the Prime Ministers were chosen not by a political party but by the king; secondly, that most Members of Parliament were not properly elected but chosen by the owner of a pocket or rotten borough.

Pitt was born on 28th May 1759. He was a precocious child, and was educated at home; at 7 he could write a letter in Latin, and at 15 he went up to Cambridge.

Pitt had a brief career in law before he entered Parliament for the pocket borough of Appleby. He rapidly made a name for himself as a member of his late father's opposition group led by Lord Shelburne. He campaigned unsuccessfully for parliamentary reform and spoke out against bribery and corruption. When Lord Shelburne became Prime Minister in 1782 Pitt was made Chancellor of the Exchequer.

Pitt versus Fox

Pitt tried to get the brilliant but dissipated Whig Charles Fox to join the government. Fox refused, which not only brought the ministry tumbling down but began an enmity between the two which was to last for the rest of their political lives. The next government was a coalition between Fox and North. The very same year, 1783, Fox's bill to abolish the privileges of the East India Company displeased King George III, who instructed the Lords to reject it. Then he dismissed his ministers and installed Pitt as Prime Minister. The idea seemed ludicrous. Fox commanded far more support and prophesied that Pitt's government would be out of office in three weeks. It lasted 17 years.

At first his bills were continually defeated, but his oratory and honesty gradually won him support inside and outside the House. Striking at just the right moment, he held an election in March 1784: 160 of Fox's supporters ('martyrs') were defeated, and Pitt himself was returned by Cambridge University, which he represented for the rest of his life.

Pitt's first task was to straighten out the appalling financial state of the nation. Trade was falling, and the national debt was, for those days, colossal. To stimulate trade Pitt began to reduce tariffs. He considered that, ideally, manufacturers should not be taxed at all and began that policy of freeing trade which was to be completed by Huskisson, Peel, and Gladstone. For example, the tax on tea was reduced from 119 per cent to 12 per cent. To raise revenue he imposed several new taxes and in 1797 introduced income tax. To deal with the national debt he introduced his famous 'sinking fund' in 1786, based on a fund which would accumulate at compound interest and ultimately pay off the debt. These policies inspired immense confidence.

Pitt's foreign policy was dominated by the war, first with Revolutionary and then with Napoleonic France. France declared war in 1792; she realised that war with Britain was inevitable, for she had determined to invade Belgium. This Britain could not allow. For the rest of his life Pitt laboured continually to build up and pay for coalitions against the French. Long after Pitt's death France was defeated; but that was largely due to Pitt's determination and the economic prosperity he had given Britain in the early years of the war.

William Pitt, the youngest-ever Prime Minister, addresses the House

The war radically changed Pitt's domestic policy. He shelved his schemes for parliamentary reform and concentrated on crushing any possible 'Jacobinism' (the name given to French extremism) at home. In 1793 and from 1795 to 1801 *Habeas Corpus* was suspended (this meant that people could be imprisoned indefinitely without trial). Those who advocated reforms such as a vote for every man were imprisoned or transported.

Apart from the great questions of foreign war and domestic peace, Pitt was also concerned with the question of Ireland, and in 1800 he passed the act by which Britain and Ireland were united as one country. This meant there were no further trade restrictions between them and Ireland greatly benefited. Pitt himself would have liked to have seen the Irish Catholics emancipated (given civil rights), but the King opposed his schemes. Because of this Pitt resigned on 14th March 1801 and was succeeded by Viscount Addington.

Last years

Though a brief peace with France came in 1802, Addington's ministry was a complete failure, and war broke out again the following year. The parliament and the country clamoured for Pitt, who returned as Prime Minister on 10th May 1804. His last ministry was inglorious. The war absorbed all his energies and took toll of his health. He lived to hear the wonderful news of Trafalgar, but Napoleon's great victory at Austerlitz finished him. He died on 23rd July 1806; his dying words were: 'My country! How I leave my country.'

Pitt never married. His life was devoted to the service of his country. No truer words were spoken than those at Pitt's funeral: 'What grave contains such a father, and such a son?'

SUBSCRIPTIONS

The following magazines can be sent weekly to you, or any person at home or abroad named by you, at the following rates:

ANNUAL SUBSCRIPTION

KNOWLEDGE	£5 4 0	**UNDERSTANDING SCIENCE**	£5 4 0	**FINDING OUT**	£5 4 0
TOUT L'UNIVERS (French *Knowledge*)	£7 16 0	**ANIMALS**	£5 4 0		

Cheques or postal order should be crossed and made payable to Knowledge Publications and sent to Subscription Department, Knowledge Publications, 37 Hertford Street, London, W.1.

You should indicate if you wish your subscription to start from the first issue or the current issue. Single copies of back numbers are available at the following prices:

KNOWLEDGE, UNDERSTANDING SCIENCE, ANIMALS, FINDING OUT: 2s. **TOUT L'UNIVERS: 3/6d.**

All postage and packing paid by us

Sole Distributors	Australia, Gordon & Gotch Ltd. 3/0	New Zealand, Gordon & Gotch Ltd. 2/6	South Africa, Central News Agency Ltd. 27½c	Rhodesias and Nyasaland, Kingstons Ltd. 3/0	India, Lalvani Bros. Rs 1·60

or designated the kinds of plants by Latin descriptions, far too long to be quoted every time the plant was mentioned.

In the year 1707 a genius was born in Sweden. This man, Carolus Linnaeus, interested himself in plants and animals all his life and invented the systems of classification and naming that are used by biologists today. His classification was based on the structure of the flowers, particularly the number of stamens and pistils, and his book *Genera Plantarum*, published in 1737, is regarded as the starting point of modern systematic botany.

His other invention, of even greater importance as it applied to botany and zoology, was his system of naming. By this system every 'kind' of plant (or animal) is called by two names: a *generic* one which defines its closest relationship with other species, and a *specific* one, which identifies the 'kind' exactly. Thus the plum is *Prunus domesticus* or 'domestic plum', the blackthorn *Prunus spinosus* or 'spiny plum', and the wild cherry *Prunus avium* or 'birds' plum'. Linnaeus recognised by their flowers and fruit that these three plants should be classified together in one genus (*prunus* is the Latin for plum), and he gave each one a suitable Latin specific name.

Latin was chosen because at the time scholars and scientists of all civilised countries were familiar with it. It still has the advantage that it favours no particular nation or living language.

Today these names are still used, and many more have been coined, bringing the total number of plants known up to about 200,000. The system of naming is known as the *binomial* system because each name consists of two words.

Early botanical gardens and herbariums

Probably the first garden maintained for the study of plants was Aristotle's. After Aristotle's death Theophrastus enlarged and improved it. The herbalists of the 16th and 17th centuries cultivated gardens for the study of plants, but they were interested mainly in their medicinal properties. Most of the earlier established botanical gardens of modern times originated as private gardens belonging to people who interested themselves in the study of plants.

The laboratory of a botanical institute, showing an electron microscope and a distilling apparatus

The Royal Botanical Gardens at Kew started in this way, and their early development as a scientific establishment took place under royal patronage during the 18th century. They were first opened to the public in 1841.

Specimens of plants to be preserved must be pressed and dried, and a collection of such specimens is called a *herbarium*. We do not know much about the earliest herbariums, but the one formed in the 18th century by the famous Swedish botanist Linnaeus is still in existence.

Botanical institutes

An up-to-date research institution, such as the department of botany at a university, requires a great deal of elaborate equipment. Plenty of space must be provided for both a herbarium and a library to house specimens and the vast amount of botanical literature which is needed to conduct research efficiently.

The apparatus must include microscopes, and the more fortunate institutions will have an electron microscope. This is a very intricate and costly instrument designed to magnify 40,000 times or more. By its use the most minute structures within the plant cells can be revealed. Microtomes are needed for cutting very thin sections of plant tissues, and a variety of stains and other chemical reagents are used to prepare the sections for microscopical examination. If research on plant physiology is being carried out much apparatus is needed of the kind used in chemistry and physics, and this is also true if the properties of plants are being examined for medical or industrial purposes.

Institutes concerned with breeding plants for agriculture, or for research in genetics, require extensive areas of ground to grow the plants used in

Cacti and ferns growing in a botanical garden

No. 150 Volume 13

Knowledge

Printed in Great Britain by Purnell & Sons Limited
Paulton, Nr. Bristol

Published by arrangement with
Fratelli Fabbri Editori
Milan

© 1960 Fratelli Fabbri Editori Milan

© 1962 Purnell & Sons Ltd.

Botany *Cover*
Kings versus barons, 1215–1399 *2385*
Cities of Belgium *2388*
The tiger *2390*
Cartography *2392*

contents

Athens: the first democracy *2394*
Nylon *2396*
Pollination by wind and water *2397*
Pitt the Younger *2400*

contents

experiments, and also large greenhouses where temperature and humidity can be controlled. All these things are very expensive, but the results obtained are of such value that the governments of progressive countries are willing to spend great sums of money to foster botanical research.

The future of botany

There is no branch of botany in which research can be said to be even nearly completed. In the less explored parts of the world many species of plants have yet to be discovered and described. In the field of applied botany there are still great opportunities.

Many well-known plants may have valuable properties yet to be discovered, and in the tropical forests there are probably unknown plants which could be of great service to man. In understanding the inner working of the plant all the progress that has been made is hardly more than a very good beginning.

The various branches of botany

Today botany is such a vast subject that it has to be subdivided into a number of minor sciences or branches. Most professional botanists are specialists in one or more of these branches and do not attempt to cover the whole field of botanical science.

Pure botany is the study of plants for the sake of gaining knowledge about them and without regard for their uses.

Applied botany is concerned with the relationship of plants to man. Botanical science can be applied to agriculture, forestry, and other industries whose basic raw materials are plants. The study of plants used in medicine is another important branch of applied botany. Both pure and applied botany have, of course, their own specialised branches.

Plant cytology is a difficult and technical branch of botany that deals with the plant cell and all the complicated processes that go on inside it.

Plant genetics is concerned with the way in which the characters of plants are passed down from one generation to the next. It includes the study of the chromosomes and genes inside the cell and so is allied to cytology. The geneticist also carries out carefully controlled breeding experiments often involving thousands of plants.

Plant morphology and **anatomy** are closely allied sciences which deal with the structure of plants. Morphology is concerned with external form, anatomy with internal structure.

Plant physiology is the study of the life processes of plants. It is largely an experimental science.

Descriptive or **taxonomic botany** deals with the classifying and naming of plants. It is an essential basis for all the other branches.

Palaeobotany is concerned with the past history and evolution of plant life on the earth. It involves the study of fossil plants, so the palaeobotanist must also be a geologist.

Geographical botany is the study of the distribution of plants on the earth. The collection of plants found in a region is called its flora, and there are distinct floras on the different continents.

CLASSIFICATION

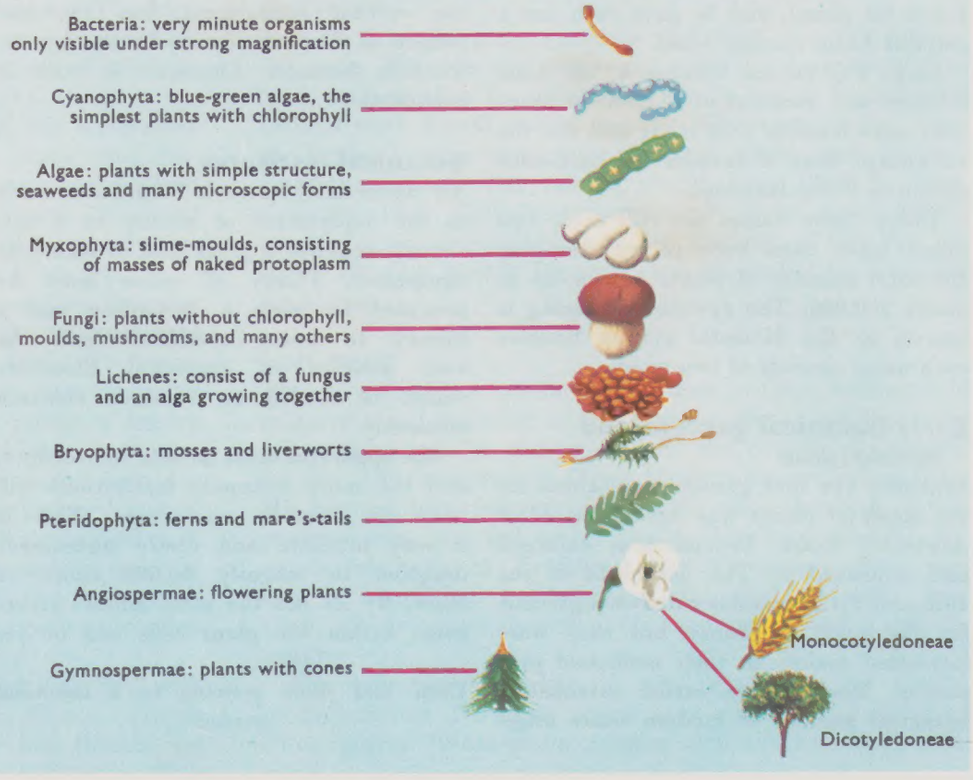
Descriptive or **taxonomic botany** is concerned with describing and classifying plants. The largest group within the Vegetable Kingdom is the Division (corresponding approximately to the Phylum in animals) and within this a plant is placed in successively smaller categories down to species.

CLASSIFICATION OF THE DAISY

Kingdom:	Vegetable
Division:	Angiospermae
Class:	Dicotyledoneae
Order:	Campanulatae
Family:	Compositae
Genus:	Bellis
Species:	perennis

The Vegetable Kingdom is classified in about 15 Divisions of which only ten are listed below. Some authorities group the Algae into several separate Divisions, including the Green, Brown, and Red Algae, and some microscopic forms.

TEN DIVISIONS OF THE VEGETABLE KINGDOM


Bacteria: very minute organisms only visible under strong magnification
Cyanophyta: blue-green algae, the simplest plants with chlorophyll
Algae: plants with simple structure, seaweeds and many microscopic forms
Myxophyta: slime-moulds, consisting of masses of naked protoplasm
Fungi: plants without chlorophyll, moulds, mushrooms, and many others
Lichenes: consist of a fungus and an alga growing together
Bryophyta: mosses and liverworts
Pteridophyta: ferns and mare's-tails
Angiospermae: flowering plants
Gymnospermae: plants with cones
Monocotyledoneae
Dicotyledoneae